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16. Abstract

Project objectives include determining the feasibility of detecting caribou aggregations, caribou trail systems, extensively cratered caribou winter feeding areas, seasonal changes in snowcover, and distribution of caribou habitat through analysis of ERTS-1 data. Present findings indicate seasonal changes in snowcover are readily mapped by sequential analysis of false color or single band transparencies of ERTS-1 scenes. Discriminate functions of ERTS-1 MSS band densities and their ratios have been generated and utilized in feature identification. Preliminary results of this analysis strongly suggest great potential for application to ecosystem mapping problems and wildlife habitat surveys. The technique can be used to detect and categorize some features which are undetectable by visual examination of images. An example of this, described in the report, is a small stream lying in dark mountain shadow. Feature categories employed in the discriminate analysis included mountain shadow with water in it, mountain shadow without water in it, lakes, Aufeis, spruce forest, muskeg, and treeless floodplain.

17. Key Words (Selected by Author(s)) ERTS Imagery, Caribou, Wildlife Habitat		18. Distribution Statement	
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I INTRODUCTION

This report summarizes the work performed and conclusions reached during the second six months of contract no. NAS5-21833, ERTS-1 project no. 110-7, "Application of ERTS-1 imagery to the study of caribou movements and winter dispersal in relation to prevailing snowcover." Research efforts during this period have been a mixture of ground truth data collection, analysis of imagery, and development of cooperative agreements for data exchange with other research agencies investigating the Porcupine caribou herd.

Data on the distribution and movements of this herd during the reporting period were collected by individual efforts of many cooperating research agencies including the Game Division of the Northwest Territorial Government, the Game Division of the Yukon Territorial Government, the Canadian Wildlife Service, I.D.S., Ltd. of Winnipeg, Manitoba, Renewable Resources of Calgary, Alberta, the Alaska Department of Fish and Game, the Arctic National Wildlife Range (U.S.B.S.F.W.), and ourselves.

The field efforts reported here include aerial reconnaissance of caribou aggregations during satellite overpass, identification of heavily used winter range areas, measurement of nival parameters in wintering areas, and aerial observation and photography of snow melt on selected winter range areas.

II. STATUS OF THE PROJECT

A. <u>Objectives</u>: Overall objectives of the project are to test the feasibility of using ERTS-1 MSS outputs to detect and map environmental features resulting from the activities of large caribou aggregations and to correlate seasonal changes in snowcover distribution with information on caribou distribution and movements. The immediate objectives during the past reporting period were:

1. To identify and precisely locate intensively used (extensively cratered) areas of winter range on the South Slopes of the mountains of Northeast Alaska.

2. To obtain ground truth data for nival parameters such as depth and hardness in these areas. Specific measurements included snow depths in cratered areas, snow depths in uncratered areas, and transects of Ramsonde profiles in both of the above.

3. To obtain aerial photography of snow melt patterns in these extensively used areas.

4. To develop cooperative relationships with other research agencies and obtain whatever data on aggregations is available for periods of satellite overpass.

5. To obtain aerial observations and photography of the large post-calving aggregations which occur in late June and early July. In this regard, two possibilities exist, namely, the post-calving aggregation of the Arctic herd

in the DeLong Mountains of Northwest Alaska and the post-calving aggregation of the Porcupine herd on the Arctic coastal plain of Northeast Alaska. Because of the limited time period during which these massive aggregations exist and because of possible adverse weather during satellite overpass, fortuitous circumstances are required for us to achieve this objective. However, if we are successful, we anticipate establishment of base-line MSS density data which will be of immense value to future analysis and realization of project objectives.

6. To characterize and define caribou habitat types in terms of MSS densities and ratios. While these definitions will vary seasonally, establishment of base-line ground truth standards will permit seasonal re-definition as often as may be necessary. The background or habitat of caribou must be determined in order to detect differences, such as the presence of caribou aggregations, against caribou-induced changes in that background.

7. To begin preliminary quantitative analysis of MSS data and investigate techniques for quantitative feature characterization in terms of digital MSS data.

B. <u>Accomplishments during the reporting period</u>

1. <u>Field accomplishments</u> - Aerial reconnaissance and ground truth data were obtained in late March. Locations of caribou aggregations, extensively cratered feeding areas, and areas which did not receive significant winter utilization were determined. Extensively cratered areas which received significant winter use were in the environs of Porcupine Lake (68° 23'N;146° 30'W), Anvil Lake (68° 23'N; 145° 40'W), Cabin Lake (68° 25'N; 146° 45'W), Vettatrin Lake (68° 30'N; 145° 04'W), and Wolf Lake (67° 33'N; 146° 11'W). These areas are representative samples of extensively cratered areas. Large areas of the Junjik valley, the East Fork and North Fork of the Chandalar, and other drainages were also extensively used by caribou during the past winter. The sample areas mentioned were selected for the following reasons: Porcupine Lake and Cabin Lake are representative of alpine areas which received significant winter use by caribou. The head waters of Deadman Creek (68° 21'N; 145° 55'W) and Bulb Lake (68° 01'N; 145° 12'W) are alpine areas which were used by caribou in the fall, but neither area received significant winter use. Anvil Lake, Vettatrin Lake, and Wolf Lake are representative of valley bottom areas which were significantly utilized by caribou during the past winter.

At each of the utilized areas, large, extensively cratered feeding sites were selected for snow measurements. Within each feeding site, snow depth data were obtained for 44 randomly selected craters and adjacent undisturbed snow. In addition, ten Ramsonde profiles were obtained for each feeding site. These profiles were equally spaced along a transect of approximately one-quarter mile through the feeding site. Nearby uncratered sites were selected for comparison and ten-point Ramsonde transects were obtained for these sites. At the alpine areas that did not receive winter utilization, the undisturbed snowcover was sampled by making ten-point Ramsonde transects through each area.

In May, these areas were revisited and aerial photography was obtained to analyze comparative differences in the rate of snow melt.

In late June, a sampling crew returned to the area to obtain detailed characterization of the vegetation in these areas. The technique used for this is a slightly modified version of Ohmann and Ream's (1971) technique. This field activity is scheduled to continue until September.

2. Data handling accomplishments - A manual system for obtaining the respective MSS band densities at selected points of interest was devised. First, an IBM printout of digital MSS densities was produced from digital tape for part of scene 1051-21002. Manual contouring of densities was effected for geographic orientation and preliminary feature identification. Features such as a mountain shadow containing a body of water, mountain shadow without water bodies in it, lakes, summer Aufeis patches, spruce forest, muskeg, and treeless floodplain were selected for analysis. The MSS band densities which most clearly delineated the feature were used to prepare a definitive overlay. For example, band 7 densities were used to delineate shadow areas and lakes; band 5 densities were used to delineate Aufeis, etc. The overlays were precisely registered to each MSS band density printout and feature outlines were transferred to each printout. Small areas containing the selected feature outlines were cut from the printouts, precisely registered to each other, and stapled together. A common pin was driven through the density picels, thus obtaining MSS density sets for each picel one at a time. As the density sets for each picel were thus obtained, these values were keypunched to IBM cards. Therefore, each card contained four variables, namely, the respective MSS band densities for a given picel. A sub-routine was written to internally generate six "new" variables from the original four variables. These six variables consisted of various ratios of band densities for each picel, as follows:

1) $\frac{MSS7}{MSS4}$

2) $\frac{MSS6}{MSS5}$

3) $\frac{MSS7}{MSS5}$

4) $\frac{(MSS7)^2}{(MSS4)\,(MSS5)}$

5) $\frac{(MSS7)^3}{(MSS4)\,(MSS5)\,(MSS6)}$

6) $\frac{(MSS6)\,(MSS7)}{(MSS4)\,(MSS5)}$

The ten variables were then entered into Biomedical Computer Program PBMD07M: Step-wise discriminate analysis and the feasibility of feature descrimination using linear functions of the variables was evaluated.

3. Preliminary investigations - In the initial run of program PBMD07M, only two groups were attempted. These groups were dark mountain shadow with a small stream in it and a valley bottom lake. Only the four band densities were used as variables in the discrimination, and the output indicated that band 6 density was the best single variable for discrimination; the next best variable for the discrimination was band 4 density. Using all four variables, the program was able to correctly classify single lake points with 72 percent accuracy and single shadow points with 62 percent accuracy.

In the second run of the program, the sub-routine was used to internally generate the six ratio variables. Once again, the discrimination involved only mountain shadow containing a stream and a valley bottom lake. Output indicated the three most useful or best variables for distinguishing between the two features were band 6 density, band 4 density, and ratio of band 6 over band 5.

Using only band 6 and band 4 densities, the program correctly classified single lake points with 84 percent accuracy, but single shadow points were correctly classified with only 50 percent accuracy. Using densities of band 6, band 4, and the ratio of band 6 over band 5, the program correctly categorized 64 percent of the lake points and 68 percent of shadow points. Using all ten variables, the program correctly classfied 68 percent of shadow points and 76 percent of the lake points.

Those "shadow" picels mis-identified as "lake" were then plotted on the original density printout. These picels were found clustered together in an oblong pattern in the northeast portion of the shadow area. Close examination of USGS photos of the area indicated that there was a small stream in this area. A total of 17 picels were involved corresponding to roughly 23 acres of surface area. This strongly suggests the capability for identification of water bodies, even when these lie in dark shadows cast by mountains.

A second mountain shadow area in which no water bodies are mapped or evident on aerial photos was selected, and the density sets for this area were keypunched on IBM cards. This new deck was used to characterize "shadow" in the discrimination, and card decks for Aufeis, muskeg, spruce forest, and treeless floodplain were added to the problem. The sub-routine to generate the six ratio "variables" was not used, and therefore, the only variables entered in the program were the four MSS band densities associated with each picel. Output from this analysis indicated the following: The best single variable for discrimination between the features was band 5 density, and this was closely followed by band 4 density. Band 6 density was also indicated to be quite useful in discrimination between categories. Band 7 densities were the least valuable in discriminations.

Initially, the program used only the band 5 density in discrimination and correctly categorized 80 percent of shadow picels, 66 percent of lake picels, 92 percent of Aufeis picels, 76 percent of spruce forest picels, and 76 percent of muskeg picels, but it did not classify any of the "treeless floodplain" picels in that category. Instead, 70 percent of these points were identified as "muskeg" by the analysis.

In a progressive step-wise fashion, the program incorporates variables in the discrimination until the last step where it uses all of the input variables. In this final output, correct categorization was only 56 percent for shadow, 46 percent for lake, 62 percent for muskeg, 56 percent for treeless floodplain, 56 percent for spruce forest, and 92 percent for Aufeis.

We concluded from this analysis that our initial categorizations were based on insufficient ground truth. The first step of the last discriminate analysis provides reasonable indication of this because none of the points which we chose to call "treeless floodplain" were so classified, but 70 percent of these picels were classified as "muskeg." This strongly suggests to us that the two areas may actually be very similar in vegetational composition. This possibility will be explored further after additional fieldwork at the site.

Another preliminary investigation during the reporting period consisted of mapping snowcover, wet tundra, and dry tundra on scene 1050-20541. A large portion of a false color transparency of this scene was visually analyzed, and a zoom transfer scope was used to superimpose these features on Dr. R. LeResche's caribou trail system map for the same area. Analyses of this type will be further investigated when the University of Alaska permanently acquires a zoom transfer scope and CDU unit.

4. Applicability of ERTS-1 data to project objectives - Mapping of seasonal changes in snowcover from sequential analysis of ERTS imagery will be relatively simple provided not too many scenes in the sequence are cloud covered. Using a zoom transfer scope, false color transparencies or single band 9.5-inch transparencies can be projected to scale on a map. The scenes can then be visually analyzed and snow lines can be transferred directly to the map or to a plastic overlay covering the map.

Step-wise linear discriminate analysis presently appears to show great promise for application to and successful realization of project objectives. The most critical aspect of such analyses is obtaining accurate reasonably homogenous ground truth data to provide base-line standards for generation of the discriminate functions. During the past reporting period, detailed ground truth of snow conditions, precise locations of extensively cratered winter feeding areas, and small aggregations of caribou was obtained on March 27. ERTS-1 scene 1247-20500 on that date is cloud-free over portions of our ground truth area. Consequently, discriminate analysis of digital MSS density data will be applied to identification of cratered areas.

At this stage of project completion, it seems certain that we will be at least partially successful in realization of project objectives. However, definitive characterization of both large caribou aggregations and habitat are integral to complete realization of objectives.

To date, our results indicate ERTS MSS data has great potential application to wildlife habitat surveys and long-term ecological studies of plant community succession.

5. Results - Step-wise linear discriminate analysis of selected portions of scene 1051-21002 has demonstrated the feasibility of feature identification by using discriminate functions of ERTS MSS band densities and their ratios. Our analysis indicated that features such as small streams can be detected even when they are in dark mountain shadow. Further, indications are that areas as small as 1.2 acres (1 picel) can be categorized by discriminate functions of MSS band densities. Therefore, because of the high sensitivity of the technique, ground truth areas to be used as base-line standards for function generation must be very carefully selected.

Another result obtained during the reporting period is a map overlay of wet tundra, dry tundra, and snowcover. This overlay was produced by visual analysis of a false color transparency of scene 1050-20541. The transparency was projected to scale with a zoom transfer scope onto a mapping of caribou trail systems. The features were hand drawn onto a plastic overlay superimposed on the trail system map.

6. Other - Reciprocal cooperative agreements for exchange of data were made with the Alaska Department of Fish and Game, Canadian wildlife research agencies, and several private consulting firms working on the international Porcupine herd. Additionally, an agreement was made with the staff of the Arctic National Wildlife Range. These personnel will contribute aircraft support for our vegetation sampling crew during the coming summer.

III. NEW TECHNOLOGY

None.

IV. PLANS FOR NEXT REPORTING PERIOD

Data for vegetative characterization of plant communities comprising caribou winter range in Northeast Alaska will be obtained. Sampling stands will be selected from air photos according to the following criteria: They must be relatively homogenous without apparent vegetational discontinuities, at least 50 acres in size, and representative of a major vegetation type of the area, namely, spruce forest, treeless bog, alpine tundra and moist tundra. The technique used will be slightly modified version of Ohmann and Ream's (1971) basic technique for characterization of wilderness plant communities. It is anticipated this field activity will continue through the first week of September.

In early September, analysis of imagery will resume and emphasize feature characterization in terms of digital MSS densities and their ratios. In this regard, digital tape for scene 1247-20500 will be analyzed for extensively cratered winter feeding areas. The portions of this scene for which we have ground truth are cloud-free. Additionally, tapes will be ordered for selected scenes in June and/or July. These scenes will be analyzed for the large post-calving aggregations of the Arctic and Porcupine herds. Unfortunately, it now appears that the large aggregations of the Arctic herd were under heavy cloud cover during both the overpasses in late June and early July. The object of this analysis is development of a discriminate function for caribou based on digital MSS data. Using this function as a base-line standard, selected spring scenes will be analyzed for smaller migrational aggregations of caribou. In this regard, development of some type of habitat filtering or concurrent identifying functions is anticipated. That is, program modification will be required to either permit simultaneous identification of feature categories which are not mutually exclusive, such as "caribou" and "moist tundra," or a filtration function which screens out digital MSS habitat data.

It is anticipated that the spectral signatures of both caribou and habitat will vary somewhat with season. However, if our preliminary investigations further verify the feasibility of practical application of these techniques, it should be possible to re-define discriminate functions seasonally as needed.

Based upon findings of the above analyses, feature enhancement with the CDU unit will be attempted for selected scenes. Emphasis on enhancement of caribou aggregations and their winter feeding areas is currently anticipated.

V. CONCLUSIONS

Discriminate functions based on ERTS-1 digital MSS data are powerful analytic tools with great potential use in small scale feature identification. Present indications suggest that features covering as little as 1.2 acres may be identified with this technique. Successful use of the technique, however, requires critical selection of base-line standard ground truth areas to be used for generation of the discriminate functions. Our present findings seem to indicate that these base-line areas should be no smaller than 50 acres and relatively homogenous in vegetative composition. Consequently, the technique may be easiest to apply to Arctic ecosystems where vegetation is less diverse and generally less complex than the vegetation of more temperate or tropical regions.

Because ERTS-1 MSS bands have discrete spectral widths, analytic identifications based upon functions of ERTS-1 MSS band densities are decisions which are made by evaluation of statistical probabilities. However, the limits of potential analytic application have not yet been even roughly defined or evaluated. Our findings indicate it is possible to "see" through dark shadows and identify at least some features, such as water bodies.

While any specific surface area on earth may have several or more spectral identities resulting from seasonal, diurnal, and biological changes, it should be possible, using established base-line standards to re-define functional identities, based on ERTS MSS band densities, as often as necessary. Therefore, the application of ERTS imagery to habitat mapping problems and land classification, particularly Arctic ecosystems, seems quite feasible. Simultaneous categorization of features which are not mutually exclusive should also be possible, e.g., "lake" in "shadow," "caribou aggregation" on "moist tundra," etc. To realize potential applications, however, additonal goal-oriented research is necessary to determine the limitations and categorical resolutions possible in application of linear and other functional multispectral analyses to the ERTS-1 data system.

VI. RECOMMENDATIONS

None.

VII. PUBLICATIONS

A manuscript on "Nival Characteristics of Caribou Winter Range in Northeast Alaska" is currently in preparation.

VIII REFERENCES

Ohmann, L.F. and R.R. Ream. 1971. Wilderness ecology: A method of sampling and summarizing data for plant community classification. U.S.D.A. Forest Service Research Paper NC-49. North Central Forest Experiment Station. St. Paul, Minn. 14 pp.

APPENDIX A - CHANGES IN STANDING ORDER FORM

None.

APPENDIX B

Data Request Form:

Submitted one for digital tapes on July 20, 1973

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

NDPF USE ONLY
D
N
ID

DATE July 31, 1973

PRINCIPAL INVESTIGATOR Peter C. Lent

GSFC U682

ORGANIZATION ACWRU

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	River	Cloud	Mtns.	
1258-20095	X	X		
1258-20101	X	X	X	
1258-20104	X	X	X	Shadow
1258-20110	X	X	X	Snow line
1263-20380	X	X	X	Arctic coast
1263-20383	X		X	River drainages
1263-20385	X		X	Snow melt
1263-20392	X		X	Major river
1263-20394	X		X	Glacial river
1267-21012	X	X	X	
1267-21015	X	X	X	Snow melt
1269-21125	X		X	Snow melt
1270-19364	X		X	Snow melt
1279-20265	X		X	River delta
1279-20272	X	X	X	Orographic cumulus
1279-20274	X	X	X	Snow melt
1279-20281	X	X	X	Snow melt

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
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APPENDIX D

SIXTH BI-MONTHLY PROGRESS REPORT
UNIVERSITY OF ALASKA
ERTS PROJECT 110-7
July 31, 1973

PRINCIPAL INVESTIGATOR: Peter C. Lent

TITLE OF INVESTIGATION: Application of ERTS-1 imagery to the study of caribou movements and winter dispersal in relation to prevailing snowcover

DISCIPLINE: Environment

SUBDISCIPLINE: Phenology/Wildlife Habitat Surveys

SUMMARY OF SIGNIFICANT RESULTS: Ground truth data collection was in progress during the reporting period and is continuing. Therefore, no new analytic findings were produced during this reporting period.